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CAFFEINE, ALERTNESS AND SIMPLE REACTION TIME: A STUDY OF FREE CHOICE OF BEVERAGES

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ABSTRACT

Background: There has been extensive research on the behavioural effects of caffeine, with most studies being conducted in the laboratory. Epidemiological studies have examined the effects of regular consumption patterns, but often the accuracy of measurement of caffeine consumption is low. There is a need to examine the effects of caffeine consumption in free-living participants, and that was the aim of the present study. **Methods:** Twenty three participants completed a cross-over study where they were provided with decaffeinated coffee and tea on one day and caffeinated products on the other. The caffeine manipulation was double-blind. After consuming their normal breakfast, the participants visited the laboratory at 08.00 and carried out alertness ratings and a simple

reaction time task. They also collected the coffee and tea at this time. Participants recorded their consumption of the coffee and tea and returned to the laboratory at 17.00. **Results:** The alertness and reaction times scores were transformed to per cent change from baseline. On the day consuming caffeinated products, the percentage increase in alertness was significantly higher than on the day consuming decaffeinated products. On the decaffeinated day, volunteers had a greater increase in simple reaction time than on the caffeine day. The beneficial effect of caffeine was greater in the high consumers. Alertness at the start of the day predicted subsequent consumption of caffeinated beverages, with lower alertness at that time being associated with greater subsequent consumption. **Conclusion:** These results demonstrate that when individuals are free to consume as many caffeinated or decaffeinated cups of coffee and tea, the caffeinated products lead to higher alertness and faster simple reaction time in the late afternoon. Those who consumed higher amounts of caffeine showed

greater benefits than the low consumers. Lower alertness in the early morning led to greater consumption of caffeinated beverages. Overall, these results confirm that consumption of caffeine reduces the build-up of fatigue over the day, which has strong implications for safety-critical activities.

KEYWORDS: Caffeine; free consumption; alertness; simple reaction time.

INTRODUCTION

There has been extensive research on the effects of caffeine on behaviour. Most of the research has involved laboratory studies. This can be seen when one considers the bibliography of our caffeine research^[1-68], where 78.7% of the articles describe laboratory studies, 7.5% epidemiological research on effects of regular consumption patterns, and 13.4% position papers and reviews. What is obviously missing is research on the effects of free-living individuals who can consume caffeinated products when they feel like it. One study^[25] has used this approach and found that those who consumed greater amounts of caffeine over a week reported greater alertness and had faster reaction time at the end of the working day. One problem with this study was that although the number of beverages were recorded, the strength of the brews (i.e. the amount of caffeine per drink) was calculated from general information on caffeine content, not the actual amount delivered. This was controlled here by providing the participants with products and showing them the amounts to use and how to make the beverages. Both coffee and tea were provided, with coffee being consumed up to 14.00 and tea after that. On separate days caffeinated and decaffeinated versions of the products were provided, the two conditions being in a counterbalanced order.

Alertness and reaction time were assessed using the “after-effect” technique^[69], which involved measurement of the alertness and reaction time at 08.00 and 17.00. The difference between the two times gives a good indication of how fatigued the person has been over the day. The present study not only compared days when caffeinated and decaffeinated products were consumed but also examined the effects of consumption level. The study also investigated whether alertness level influenced subsequent consumption of caffeinated drinks. Consumption of caffeine shows a strong diurnal trend, with early morning and post-lunch being periods of high consumption. It was predicted that lower alertness levels would be associated with greater subsequent consumption.

METHODS

The research reported here was carried out with the approval of the ethics committee, Department of Psychology, and carried out with the informed consent of the participants.

Design

A cross-over design was used with each participant consuming both caffeinated and decaffeinated products, the order of which was counterbalanced. A double-blind design was used, with neither the experimenters nor the participants knowing whether they had caffeinated or decaffeinated products.

Participants

The twenty-three volunteers who took part in the study were all working full time (e.g. clerical/technical staff) and were selected from workplaces in or near the University (within a 15-minute walk). The criteria by which subjects were selected were: no more than 20 units of alcohol per week and no more than ten cigarettes per day. They also had to be unrestricted in times of consuming beverages. There were approximately equal numbers of the two sexes (12F, 11M), and the median age was 34 years (range 30-37 years). 13% were smokers, and the mean weekly alcohol consumption was 9.3 units (range 5.8-12.8 units). Total daily caffeine consumption was 263 mg (range 199-327 mg).

Procedure

Prior to participation in the experiment, participants underwent a 20-minute familiarisation session, during which they were given a thorough description of the study. They also learnt how to use the computer tasks and were instructed on daily procedures. They were also provided with a booklet for the purpose of gathering pertinent information such as mood, food and drink consumption, cigarette and alcohol use, exercise undertaken and a sleep log. They received a new booklet on each test day. On the test days, between getting up and arriving at the laboratory, they were free to consume their preferred caffeinated drink with breakfast. Having performed the alertness rating and simple reaction time task, they were provided with the appropriate drink supplies for the rest of the day. Instant coffee was provided, and a teaspoon was added to 150 ml of boiling water. Teabags were also provided. Milk and sugar were added to taste. In both conditions, participants were able to consume non-caffeinated drinks, such as water, fruit juice and milk.

Alertness and Simple reaction time

Alertness was assessed using visual analogue rating scales (e.g. drowsy-alert; energetic-lethargic).

A variable fore period simple reaction time task lasting 3 minutes was used. In this task, a box was displayed on the screen, and at varying intervals (from 1 to 8 seconds), a square would appear in the box. Participants were required to press a response key as soon as they detected the square. Reaction time was measured to the nearest millisecond.

RESULTS

Amount of caffeine consumed

In the caffeine condition, the mean amount of caffeine consumed was 319.3 mg (s.s. 38.4).

Alertness

In the caffeinated condition, alertness increased over the day (mean per cent change = 4.38%, s.e. 3.89%). In contrast, alertness decreased in the decaffeinated condition (mean percent change: -6.93%, s.e. = 3.15%). The difference between conditions was significant ($p < 0.002$).

Alertness was significantly negatively correlated with subsequent caffeine consumption ($r = -0.51$, $p < 0.05$).

Simple RT

In the caffeinated condition, RT later in the day was very similar to the morning (mean per cent change: -0.03%, s.e. = 1.73%), whereas RT was slower later in the day in the decaffeinated condition (mean per cent change: 4.59%, s.e. = 2.01%). The difference between conditions was significant ($p < 0.05$, 1-tail).

Those who consumed more caffeine over the day, based on a median split, had faster RTs later in the day than those who consumed less caffeine (high consumers: mean per cent change: -4.40%; low consumers: mean per cent change: 4.37%; $p < 0.05$, 1-tail).

DISCUSSION

The majority of studies of caffeine and behaviour have conducted research in the laboratory, often looking at the acute effects of a single dose. Two robust findings from this research are that caffeine increases alertness and leads to faster simple reaction time.^[24, 51-56, 72, 73] The

present study examined this issue in a real-life situation, where the participants could consume caffeinated drinks when they wanted to. Caffeinated and decaffeinated coffee and tea were compared in a double-blind cross-over study. Alertness and reaction time were measured at 08.00 and 17.00, the rationale being that the difference between these measurements reflected the degree of fatigue over the day. The results confirmed the predictions of greater alertness and faster reaction time after caffeine. A dose-response effect was observed, with those consuming greater amounts of caffeine showing greater benefits than those consuming smaller amounts. Plausible biological mechanisms underlying the alerting effects of caffeine have been put forward.^[72-74]

Consumption of caffeine often shows a clear diurnal trend with greater ingestion in the early morning and the post-lunch period. The present results showed a strong correlation between alertness level and the amount of subsequent caffeine consumption, which provides a mechanism for the diurnal trend. One explanation of both caffeine consumption and the behavioural effects is that caffeine reverses the negative effects of withdrawal.^[75] In the present study, participants consumed caffeinated drinks at breakfast time on both caffeine and decaffeinated days, which meant they were not withdrawn when they consumed subsequent drinks. The dose-response found in the caffeine data also suggests that an explanation based on withdrawal reversal is unlikely. This is consistent with other evidence against the withdrawal hypothesis.^[10, 11, 12, 17, 22, 38, 50-54]

CONCLUSION

The results from the present study confirm the findings from many laboratory studies. Caffeine was associated with increased alertness and faster simple reaction time. Those who consumed more caffeine showed greater benefits than those who consumed less caffeine. Alertness levels were also associated with subsequent consumption of caffeine, with those with lower alertness being more likely to consume caffeinated beverages. These results have practical implications and may be especially relevant to those doing safety critical jobs.

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